

WHAT IS CLAIMED IS:

1. A catalyst for trimerization of ethylene which comprises:

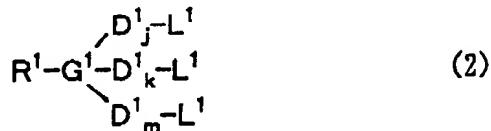
(i) an organometallic complex having a neutral multidentate ligand having a tripod structure, represented by the following formula (1):



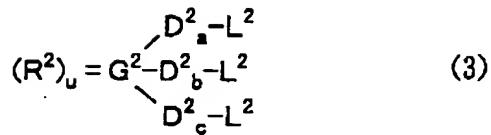
wherein A is a neutral multidentate ligand having a tripod structure, M is a transition metal atom of group 3 to group 10 of the periodic table, each Q is independently selected from the group consisting of a hydrogen atom, a halogen atom, a straight chain or branched alkyl group having 1 to 10 carbon atoms which may have a substituent, an aryl group having 6 to 10 carbon atoms which may have a substituent, and n is an integer equal to a formal oxidation valence of M, and

(ii) an alkylaluminoxane;

said neutral multidentate ligand A in formula (1) being a tridentate ligand represented by the following formula (2) or formula (3):



wherein j, k and m independently represent an integer of 0 to 6, each D^1 independently represents a divalent hydrocarbon group which may have a substituent, each L^1 independently represents a substituent containing an element of group 14, 15, 16 or 17 of the periodic table, with the proviso that all of the three L^1 's are not concurrently a substituent containing an element of group 14 or 17, G^1 represents a carbon or silicon atom, and R^1 represents a hydrogen atom, an alkyl group having 1 to 10 carbon atoms which may have a substituent, or an aryl group having 6 to 10 carbon atoms which may have a substituent;



wherein a, b and c independently represent an integer of 0 to 6; u represents an integer of 0 or 1; each D^2 independently represents a divalent hydrocarbon group which may have a substituent; each L^2 independently represents a substituent containing an element of group 14, 15, 16 or 17 of the periodic table, with the proviso that all of the three L^2 's are not concurrently a substituent containing an element an element of group 14 or 17, G^2 represents a nitrogen or phosphorus atom when u is 0, or a phosphorus atom when u is 1, and R^2 represents an oxygen or sulfur atom.

2. A catalyst for trimerization of ethylene which comprises:

(i) an organometallic complex having a neutral multidentate ligand having a tripod structure, represented by the following formula (1):

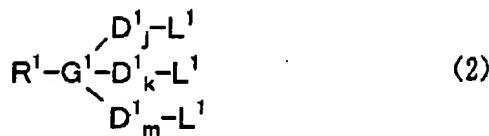


wherein A is a neutral multidentate ligand having a tripod structure, M is a transition metal atom of group 3 to group 10 of the periodic table, each Q is independently selected from the group consisting of a hydrogen atom, a halogen atom, a straight chain or branched alkyl group having 1 to 10 carbon atoms which may have a substituent, an aryl group having 6 to 10 carbon atoms which may have a substituent, and n is an integer equal to a formal oxidation valence of M, and

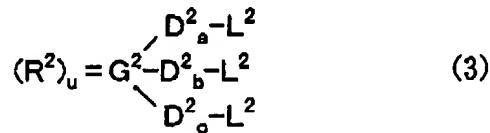
(ii) an alkylaluminoxane, and

(iii) a halogenated inorganic compound;

said neutral multidentate ligand A in formula (1) being a tridentate ligand represented by the following formula (2) or formula (3):



wherein j, k and m independently represent an integer of 0 to 6, each D^1 independently represents a divalent hydrocarbon group which may have a substituent, each L^1 independently represents a substituent containing an element of group 14, 15, 16 or 17 of the periodic table, with the proviso that all of the three L^1 's are not concurrently a substituent containing an element of group 14 or 17, G^1 represents a carbon or silicon atom, and R^1 represents a hydrogen atom, an alkyl group having 1 to 10 carbon atoms which may have a substituent, or an aryl group having 6 to 10 carbon atoms which may have a substituent;



wherein a, b and c independently represent an integer of 0 to 6; u represents an integer of 0 or 1; each D^2 independently represents a divalent hydrocarbon group which may have a substituent; each L^2 independently represents a substituent containing an element of group 14, 15, 16 or 17 of the periodic table, with the proviso that all of the three L^2 's are not concurrently a substituent containing an element an element of group 14 or 17, G^2 represents a nitrogen or phosphorus atom when u is 0, or a phosphorus atom when u is 1, and R^2 represents an oxygen or sulfur atom.

3. A catalyst for trimerization of ethylene which comprises:

(i) an organometallic complex having a neutral multidentate ligand having a tripod structure, represented by the following formula (1):



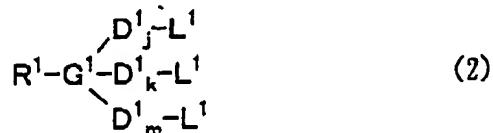
wherein A is a neutral multidentate ligand having a tripod structure, M is a transition metal atom of group 3 to group 10 of the periodic table, each Q is independently selected from the group consisting of a hydrogen atom, a halogen atom, a straight chain or branched alkyl group having 1 to 10 carbon atoms which may have a substituent, an aryl group having 6 to 10 carbon atoms which may have a substituent, and n is an integer equal to a formal oxidation valence of M.

- (ii) an alkylaluminoxane,
- (iii) a halogenated inorganic compound, and
- (iv) an alkyl group-containing compound represented by the following formula (4):



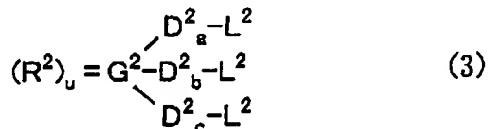
wherein p and q are numbers satisfying the formulae: $0 < p \leq 3$ and $0 \leq q < 3$, provided that $(P + q)$ is in the range of 1 to 3, E represents an atom, other than a hydrogen atom, of group 1, 2, 3, 11, 12 or 13 of the periodic table, each R independently represents an alkyl group having 1 to 10 carbon atoms, and each J independently represents a hydrogen atom, an alkoxide group having 1 to 10 carbon atoms, an aryloxy group having 6 to 10 carbon atoms, an aryl group having 6 to 10 carbon atoms or a halogen atom;

said neutral multidentate ligand A in formula (1) being a tridentate ligand represented by the following formula (2) or formula (3):



wherein j, k and m independently represent an integer of 0 to 6, each D^1 independently represents a divalent hydrocarbon group which may have a substituent, each L^1 independently represents a substituent containing an element of group 14, 15, 16 or 17 of the periodic table, with the proviso that all of the three

L's are not concurrently a substituent containing an element of group 14 or 17, G¹ represents a carbon or silicon atom, and R¹ represents a hydrogen atom, an alkyl group having 1 to 10 carbon atoms which may have a substituent, or an aryl group having 6 to 10 carbon atoms which may have a substituent;



wherein a, b and c independently represent an integer of 0 to 6; u represents an integer of 0 or 1; each D² independently represents a divalent hydrocarbon group which may have a substituent; each L² independently represents a substituent containing an element of group 14, 15, 16 or 17 of the periodic table, with the proviso that all of the three L²'s are not concurrently a substituent containing an element of group 14 or 17, G² represents a nitrogen or phosphorus atom when u is 0, or a phosphorus atom when u is 1, and R² represents an oxygen or sulfur atom.

4. A catalyst for trimerization of ethylene which comprises:

(i) an organometallic complex having a neutral multidentate ligand having a tripod structure, represented by the following formula (1):



wherein A is a neutral multidentate ligand having a tripod structure, M is a transition metal atom of group 3 to group 10 of the periodic table, each Q is independently selected from the group consisting of a hydrogen atom, a halogen atom, a straight chain or branched alkyl group having 1 to 10 carbon atoms which may have a substituent, an aryl group having 6 to 10 carbon atoms which may have a substituent, and n is an integer equal to a formal oxidation valence of M,

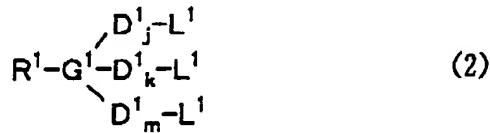
(ii) an alkylaluminoxane, and

(iii) an alkyl group-containing compound represented by the following formula (4):

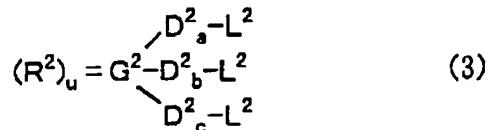


wherein p and q are numbers satisfying the formulae: $0 < p \leq 3$ and $0 \leq q < 3$, provided that $(P + q)$ is in the range of 1 to 3, E represents an atom, other than a hydrogen atom, of group 1, 2, 3, 11, 12 or 13 of the periodic table, each R independently represents an alkyl group having 1 to 10 carbon atoms, and each J independently represents a hydrogen atom, an alkoxide group having 1 to 10 carbon atoms, an aryloxy group having 6 to 10 carbon atoms, an aryl group having 6 to 10 carbon atoms or a halogen atom;

said neutral multidentate ligand A in formula (1) being a tridentate ligand represented by the following formula (2) or formula (3):



wherein j, k and m independently represent an integer of 0 to 6, each D^1 independently represents a divalent hydrocarbon group which may have a substituent, each L^1 independently represents a substituent containing an element of group 14, 15, 16 or 17 of the periodic table, with the proviso that all of the three L^1 's are not concurrently a substituent containing an element of group 14 or 17, G^1 represents a carbon or silicon atom, and R^1 represents a hydrogen atom, an alkyl group having 1 to 10 carbon atoms which may have a substituent, or an aryl group having 6 to 10 carbon atoms which may have a substituent;



wherein a, b and c independently represent an integer of 0 to

6; u represents an integer of 0 or 1; each D² independently represents a divalent hydrocarbon group which may have a substituent; each L² independently represents a substituent containing an element of group 14, 15, 16 or 17 of the periodic table, with the proviso that all of the three L²'s are not concurrently a substituent containing an element an element of group 14 or 17, G² represents a nitrogen or phosphorus atom when u is 0, or a phosphorus atom when u is 1, and R² represents an oxygen or sulfur atom.

5. A catalyst for trimerization of ethylene which comprises:

(i) an organometallic complex having a neutral multidentate ligand having a tripod structure, represented by the following formula (1):

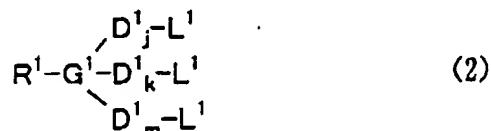


wherein A is a neutral multidentate ligand having a tripod structure, M is a transition metal atom of group 3 to group 10 of the periodic table, each Q is independently selected from the group consisting of a hydrogen atom, a halogen atom, a straight chain or branched alkyl group having 1 to 10 carbon atoms which may have a substituent, an aryl group having 6 to 10 carbon atoms which may have a substituent, and n is an integer equal to a formal oxidation valence of M.

(ii) an alkylalumininoxane, and

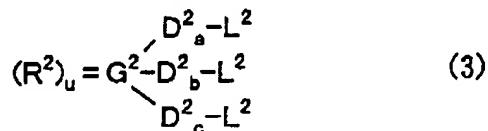
(iii) at least one compound selected from the group consisting of an amine compound and an amide compound;

said neutral multidentate ligand A in formula (1) being a tridentate ligand represented by the following formula (2) or formula (3):



wherein j, k and m independently represent an integer of 0 to

6, each D¹ independently represents a divalent hydrocarbon group which may have a substituent, each L¹ independently represents a substituent containing an element of group 14, 15, 16 or 17 of the periodic table, with the proviso that all of the three L¹'s are not concurrently a substituent containing an element of group 14 or 17, G¹ represents a carbon or silicon atom, and R¹ represents a hydrogen atom, an alkyl group having 1 to 10 carbon atoms which may have a substituent, or an aryl group having 6 to 10 carbon atoms which may have a substituent;



wherein a, b and c independently represent an integer of 0 to 6; u represents an integer of 0 or 1; each D² independently represents a divalent hydrocarbon group which may have a substituent; each L² independently represents a substituent containing an element of group 14, 15, 16 or 17 of the periodic table, with the proviso that all of the three L²'s are not concurrently a substituent containing an element of group 14 or 17, G² represents a nitrogen or phosphorus atom when u is 0, or a phosphorus atom when u is 1, and R² represents an oxygen or sulfur atom.

6. A catalyst for trimerization of ethylene which comprises:

(i) an organometallic complex having a neutral multidentate ligand having a tripod structure, represented by the following formula (1):



wherein A is a neutral multidentate ligand having a tripod structure, M is a transition metal atom of group 3 to group 10 of the periodic table, each Q is independently selected from the group consisting of a hydrogen atom, a halogen atom, a straight chain or branched alkyl group having 1 to 10 carbon

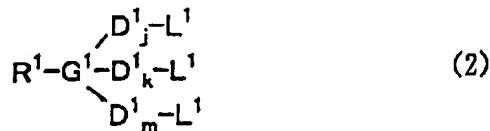
atoms which may have a substituent, an aryl group having 6 to 10 carbon atoms which may have a substituent, and n is an integer equal to a formal oxidation valence of M,

- (ii) an alkylaluminoxane,
- (iii) at least one compound selected from the group consisting of an amine compound and an amide compound, and
- (iv) an alkyl group-containing compound represented by the following formula (4):



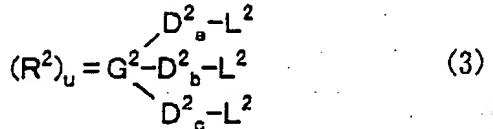
wherein p and q are numbers satisfying the formulae: $0 < p \leq 3$ and $0 \leq q < 3$, provided that $(P + q)$ is in the range of 1 to 3, E represents an atom, other than a hydrogen atom, of group 1, 2, 3, 11, 12 or 13 of the periodic table, each R independently represents an alkyl group having 1 to 10 carbon atoms, and each J independently represents a hydrogen atom, an alkoxide group having 1 to 10 carbon atoms, an aryloxy group having 6 to 10 carbon atoms, an aryl group having 6 to 10 carbon atoms or a halogen atom;

said neutral multidentate ligand A in formula (1) being a tridentate ligand represented by the following formula (2) or formula (3):



wherein j, k and m independently represent an integer of 0 to 6, each D^1 independently represents a divalent hydrocarbon group which may have a substituent, each L^1 independently represents a substituent containing an element of group 14, 15, 16 or 17 of the periodic table, with the proviso that all of the three L^1 's are not concurrently a substituent containing an element of group 14 or 17, G^1 represents a carbon or silicon atom, and R^1 represents a hydrogen atom, an alkyl group having 1 to 10 carbon atoms which may have a substituent, or an aryl group having 6

to 10 carbon atoms which may have a substituent;



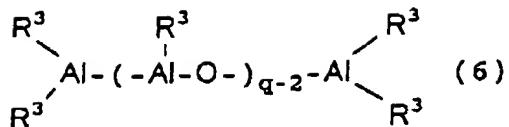
wherein a, b and c independently represent an integer of 0 to 6; u represents an integer of 0 or 1; each D^2 independently represents a divalent hydrocarbon group which may have a substituent; each L^2 independently represents a substituent containing an element of group 14, 15, 16 or 17 of the periodic table, with the proviso that all of the three L^2 's are not concurrently a substituent containing an element an element of group 14 or 17, G^2 represents a nitrogen or phosphorus atom when u is 0, or a phosphorus atom when u is 1, and R^2 represents an oxygen or sulfur atom.

7. A catalyst for trimerization of ethylene according to any one of claims 1 to 6, wherein said organometallic complex having a neutral multidentate ligand having a tripod structure is an organochromium complex represented by formula (1) wherein M is a chromium atom.

8. A catalyst for trimerization of ethylene according to any one of claims 1 to 6, wherein a neutral multidentate ligand having a tripod structure A is facially coordinated to a transition metal atom M of group 3 to group 10 of the periodic table in the organometallic complex of formula (1).

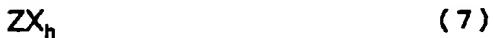
9. A catalyst for trimerization of ethylene according to any one of claims 1 to 6, the alkylaluminoxane is at least one compound selected from the group consisting of compounds represented by the following formulae (5) and (6):





wherein each R^3 independently represents a hydrogen atom or a hydrocarbon group having 1 to 20 carbon atoms, and q is an integer of 2 to 60.

10. A catalyst for trimerization of ethylene according to claim 2 or 3, the halogenated inorganic compound is represented by the following formula (7):



wherein Z is an atom of group 1, 2, 13, 14 or 15 of the periodic table, X represents a halogen atom, and h denoting a number of X is a natural number equal to the formal oxidation valence of Z .

11. A catalyst for trimerization of ethylene according to claim 5 or 6, wherein each of the amine compound and the amide compound has at least one nitrogen atom having three substituents other than hydrogen atoms, and has 3 to 30 carbon atoms.

12. A process for trimerizing ethylene wherein ethylene is trimerized in the presence of a catalyst as claimed in any one of claims 1 to 6.

13. A process for trimerizing ethylene wherein ethylene is trimerized in the presence of a catalyst as claimed in any one of claims 1 to 6;

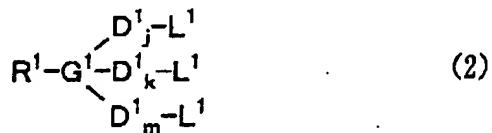
said catalyst being prepared by a step comprising placing (i) an organometallic complex having a neutral multidentate ligand having a tripod structure, in contact with (ii) an alkylaluminoxane in the presence of ethylene;

said organometallic complex having a neutral multidentate ligand having a tripod structure being represented by the following formula (1):

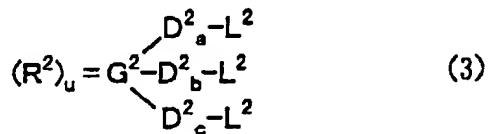


wherein A is a neutral multidentate ligand having a tripod structure, M is a transition metal atom of group 3 to group 10 of the periodic table, each Q is independently selected from the group consisting of a hydrogen atom, a halogen atom, a straight chain or branched alkyl group having 1 to 10 carbon atoms which may have a substituent, an aryl group having 6 to 10 carbon atoms which may have a substituent, and n is an integer equal to a formal oxidation valence of M.

said neutral multidentate ligand A in formula (1) being a tridentate ligand represented by the following formula (2) or formula (3):



wherein j, k and m independently represent an integer of 0 to 6, each D^1 independently represents a divalent hydrocarbon group which may have a substituent, each L^1 independently represents a substituent containing an element of group 14, 15, 16 or 17 of the periodic table, with the proviso that all of the three L^1 's are not concurrently a substituent containing an element of group 14 or 17, G^1 represents a carbon or silicon atom, and R^1 represents a hydrogen atom, an alkyl group having 1 to 10 carbon atoms which may have a substituent, or an aryl group having 6 to 10 carbon atoms which may have a substituent;



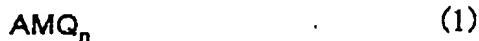
wherein a, b and c independently represent an integer of 0 to 6; u represents an integer of 0 or 1; each D^2 independently represents a divalent hydrocarbon group which may have a substituent; each L^2 independently represents a substituent containing an element of group 14, 15, 16 or 17 of the periodic table, with the proviso that all of the three L^2 's are not

concurrently a substituent containing an element an element of group 14 or 17, G² represents a nitrogen or phosphorus atom when u is 0, or a phosphorus atom when u is 1, and R² represents an oxygen or sulfur atom.

14. A process for trimerizing ethylene wherein ethylene is trimerized in the presence of a catalyst as claimed in any one of claims 3, 4 and 6;

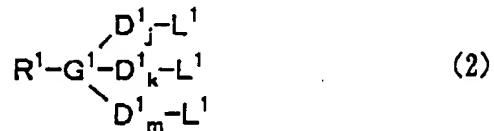
said catalyst being prepared by a step comprising placing (i) an organometallic complex having a neutral multidentate ligand having a tripod structure, in contact with (ii) an alkylaluminoxane and (iii) an alkyl group-containing compound in the presence of ethylene;

said organometallic complex having a neutral multidentate ligand having a tripod structure (i) being represented by the following formula (1):



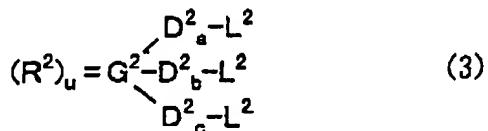
wherein A is a neutral multidentate ligand having a tripod structure, M is a transition metal atom of group 3 to group 10 of the periodic table, each Q is independently selected from the group consisting of a hydrogen atom, a halogen atom, a straight chain or branched alkyl group having 1 to 10 carbon atoms which may have a substituent, an aryl group having 6 to 10 carbon atoms which may have a substituent, and n is an integer equal to a formal oxidation valence of M.

said neutral multidentate ligand A in formula (1) being a tridentate ligand represented by the following formula (2) or formula (3):



wherein j, k and m independently represent an integer of 0 to 6, each D¹ independently represents a divalent hydrocarbon group which may have a substituent, each L¹ independently represents

a substituent containing an element of group 14, 15, 16 or 17 of the periodic table, with the proviso that all of the three L¹'s are not concurrently a substituent containing an element of group 14 or 17, G¹ represents a carbon or silicon atom, and R¹ represents a hydrogen atom, an alkyl group having 1 to 10 carbon atoms which may have a substituent, or an aryl group having 6 to 10 carbon atoms which may have a substituent;



wherein a, b and c independently represent an integer of 0 to 6; u represents an integer of 0 or 1; each D² independently represents a divalent hydrocarbon group which may have a substituent; each L² independently represents a substituent containing an element of group 14, 15, 16 or 17 of the periodic table, with the proviso that all of the three L²'s are not concurrently a substituent containing an element of group 14 or 17, G² represents a nitrogen or phosphorus atom when u is 0, or a phosphorus atom when u is 1, and R² represents an oxygen or sulfur atom; and

said alkyl group-containing compound (iii) being represented by the following formula (4):



wherein p and q are numbers satisfying the formulae: $0 < p \leq 3$ and $0 \leq q < 3$, provided that $(P + q)$ is in the range of 1 to 3, E represents an atom, other than a hydrogen atom, of group 1, 2, 3, 11, 12 or 13 of the periodic table, each R independently represents an alkyl group having 1 to 10 carbon atoms, and each J independently represents a hydrogen atom, an alkoxide group having 1 to 10 carbon atoms, an aryloxy group having 6 to 10 carbon atoms, an aryl group having 6 to 10 carbon atoms or a halogen atom.